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Proceedings of the Regional Peer Review Meeting for the Pacific Sardine 2011 seasonal biomass and migration in British Columbia and harvest advice for 2012

Compte rendu de la réunion d'examen par les pairs de la région du Pacifique : Sardine du Pacifique – Biomasse et migration saisonnières en 2011 en Colombie-Britannique et avis sur les prélèvements pour 2012

Nanaimo BC
January 10, 2012

Sean MacConnachie
Chairperson

Vanessa Hodes
Editor

Nanaimo (Colombie-Britannique)
Le 10 janvier 2012

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Canada

Foreword

The purpose of these Proceedings is to document the activities and key discussions of the meeting. The Proceedings include research recommendations, uncertainties, and the rationale for decisions made by the meeting. Proceedings also document when data, analyses or interpretations were reviewed and rejected on scientific grounds, including the reason(s) for rejection. As such, interpretations and opinions presented in this report individually may be factually incorrect or misleading, but are included to record as faithfully as possible what was considered at the meeting. No statements are to be taken as reflecting the conclusions of the meeting unless they are clearly identified as such. Moreover, further review may result in a change of conclusions where additional information was identified as relevant to the topics being considered, but not available in the timeframe of the meeting. In the rare case when there are formal dissenting views, these are also archived as Annexes to the Proceedings.

Avant-propos

Le présent compte rendu a pour but de documenter les principales activités et discussions qui ont eu lieu au cours de la réunion. Il contient des recommandations sur les recherches à effectuer, traite des incertitudes et expose les motifs ayant mené à la prise de décisions pendant la réunion. En outre, il fait état de données, d'analyses ou d'interprétations passées en revue et rejetées pour des raisons scientifiques, en donnant la raison du rejet. Bien que les interprétations et les opinions contenues dans le présent rapport puissent être inexactes ou propres à induire en erreur, elles sont quand même reproduites aussi fidèlement que possible afin de refléter les échanges tenus au cours de la réunion. Ainsi, aucune partie de ce rapport ne doit être considérée en tant que reflet des conclusions de la réunion, à moins d'indication précise en ce sens. De plus, un examen ultérieur de la question pourrait entraîner des changements aux conclusions, notamment si l'information supplémentaire pertinente, non disponible au moment de la réunion, est fournie par la suite. Finalement, dans les rares cas où des opinions divergentes sont exprimées officiellement, celles-ci sont également consignées dans les annexes du compte rendu.

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SUMMARY

These Proceedings summarize the relevant discussions and key conclusions that resulted from a Fisheries and Oceans Canada (DFO), Canadian Science Advisory Secretariat (CSAS) Regional Advisory meeting of January 10, 2012 at the Pacific Biological Station in Nanaimo, B.C. A science advisory report focusing on the status of Pacific Sardine summer seasonal abundance and migration, based on observations from the most recent west coast of Vancouver Island survey, and harvest options for the 2012/2013 fishing season were presented for peer review.

In-person and web-based participation included DFO Science, Fisheries and Aquatic Management (FAM) sectors staff; external participants from First Nations, the Province of British Columbia, the commercial and recreational fishing sectors, and National Oceanic and Atmospheric Association (NOAA) colleagues.

The conclusions and advice resulting from this review will form the science advisory report providing advice to FAM on harvest options for the 2012/2013 fishing season

The science advisory report will be made publicly available on the CSAS Science Advisory Schedule at http://www.dfo-mpo.gc.ca/csas-sccs/index-eng.htm

SOMMAIRE

Ce compte rendu résume les principales discussions et conclusions de la réunion de consultation régionale du Secrétariat canadien de consultation scientifique (SCCS) de Pêches et Océans Canada (MPO) qui s'est tenue le 10 janvier 2012 à la Station biologique du Pacifique de Nanaimo (Colombie-Britannique). On y a présenté, aux fins d'examen par les pairs, un avis scientifique portant sur l'abondance et la migration estivales de la sardine du Pacifique, compte tenu des plus récents relevés des sardines effectués sur la côte ouest de l'île de Vancouver, et sur les niveaux de prélèvement pour la saison de pêche de 2012-2013.

Au nombre des participants qui ont assisté à la réunion en personne ou par conférence Web, il y avait notamment des représentants des secteurs des Sciences et de la Gestion des pêches et de l'aquaculture (GPA) du MPO, et des participants des Premières nations, de la province de la Colombie-Britannique, des secteurs de la pêche commerciale et récréative et des collègues de la National Oceanic and Atmospheric Association (NOAA).

Les conclusions et avis découlant de cet examen seront présentés à la GPA sous forme d'avis scientifique concernant les niveaux de prélèvement pour la saison de pêche 2012-2013.

L'avis scientifique sera rendu public dans le calendrier des avis scientifiques du SCCS, à l'adresse suivante : http://www.dfo-mpo.gc.ca/csas-sccs/index-fra.htm

INTRODUCTION

A Fisheries and Oceans Canada (DFO) Canadian Science Advisory Secretariat (CSAS), Regional Peer Review (RPR) meeting was held on January 10, 2012 at the Pacific Biological Station in Nanaimo, B.C. focusing on the status of Pacific Sardine summer seasonal abundance and migration, based on observations from the most recent west coast of Vancouver Island sardine survey, and providing harvest options for the 2012/2013 fishing season.

The Terms of Reference (TOR) for the science review (Appendix C) were developed in response to a request for advice from Fisheries and Aquaculture Management branch (FAM). Notifications of the science review and conditions for participation were sent to representatives with relevant expertise from First Nations, commercial and recreational fishing sectors, environmental non-governmental organizations, Provincial and American government agencies.

The following draft science advisory report (SAR) was prepared and made available to meeting participants prior to the meeting:

> Pacific Sardine 2011 seasonal biomass and migration in British Columbia and harvest advice for 2012 (CSAS draft SAR 2011/P16)

The meeting Chair, Sean MacConnachie, welcomed participants, reviewed the role of CSAS in the provision of peer-reviewed advice, and gave a general overview of the CSAS process. The Chair discussed the role of participants, the purpose of the various RPR publications (SAR and Proceedings), and the definition and process around achieving consensus on decisions and advice. Everyone was invited to participate fully in the discussion and to contribute knowledge to the process, with the goal of delivering scientifically defensible conclusions and advice. It was confirmed with participants that all had received copies of the Terms of Reference, agenda, and draft SAR.

The Chair reviewed the agenda (Appendix A) and the Terms of Reference (Appendix C) for the meeting, highlighting the objectives and identifying the Rapporteurs for the review. The Chair then reviewed the ground rules and process for exchange, reminding participants that the meeting was a science review and not a consultation. The room was equipped with microphones to allow remote participation by web-based attendees, and in-person attendees were reminded to address comments and questions so they could be heard by those online.

Members were reminded that everyone at the meeting had equal standing as participants and that they were expected to contribute to the review process if they had information or questions relevant to the paper being discussed. In total, 26 people participated in the RPR (Appendix B). Vanessa Hodes and Sandra Basset were identified as the Rapporteurs for the meeting.

Participants were informed that because only a SAR was being reviewed official reviewers were not identified and that everyone was responsible to review the document.

The conclusions and advice resulting from this review will be provided in the form of a Science Advisory Report to Fisheries and Aquaculture. The SAR will be made publicly

available on the CSAS Science Advisory Schedule at http://www.dfo-mpo.gc.ca/csas-sccs/index-eng.htm

REVIEW

Working Paper: Pacific Sardine 2011 seasonal biomass and migration in British Columbia and harvest advice for 2012 (CSAS draft SAR 2011/P16) by Linnea Flostrand and Jake Schweigert.
Rappoteur: Vanessa Hodes and Sandra Basset
Presenter(s): Linnea FLostrand

PRESENTATION OF WORKING PAPER

Linnea Flostrand gave a presentation which included information on:

- DFO and CSAS – 1999-2011 history of sardine harvest advice
- Population Assessment (Hill et al 2011)
  - Catch series by region
  - Model methods and changes
  - Abundance and recruitment trends
- WCVI summer sardine trawl survey and sampling results
  - Regional distribution, densities, biomass and migration
  - Fork lengths and ages
- Recent commercial sardine catches by area
- Background on inshore biomass estimation
- WCVI survey region and inshore area biomass and migration estimates (2009-2011)
- Harvest guideline results
- Topics for consideration:
  - Uncertainty in B.C. and population biomass estimates
  - Canada uses a population biomass estimate that lags 1 year from applicable fishing season.
  - Combined effects of international fishing pressures (U.S. and Canada each applying 15%).
  - Large amounts of TAC taken from individual PFMAs
  - Uncertainty over reduced forage potential for marine predators

She summarized research documents and former conclusions related to harvest guidelines reported in Ware 1999; DFO 1999; Schweigert and MacFarlane 2001; DFO 2001; Schweigert et al 2009; DFO 2009; Flostrand et al 2011, and DFO 2011a. She described how the 1999 review proposed harvest guidelines using the U.S. cut-off level and distribution factor and later reviews proposed changes to harvest guideline harvest rates (2001) and migration rates (2009 and 2011).

She briefly described information on data sets and methods associated with the population assessment conducted by U.S. analysts (Hill et al. 2011) and key changes from earlier methods and findings (Hill et al. 2010), such as spatial groupings of commercial catch data and biomass scaling including 2006-2011 acoustic survey data. She explained how resulting

changes (increases) to population biomass estimates change (reduce) corresponding harvest rates and migration rates for recent years.

In addition to information presented in the draft SAR, she presented information related to planning trawl survey and some SST satellite imagery recorded during the 2011 survey (July 25 and 27). The satellite imagery showed relatively cool waters off northeast, northwest and southwest regions of Vancouver Island believed to be related to low observed sardine densities.

Information related to 2006 to 2011 commercial seine catches by Pacific Fishery Management Area (PFMA) was also presented, followed by an explanation of how inshore (inlet) biomass expansion was calculated for the 2011 review (Flostrand et al 2011). She noted the lack of commercial sardine catches in mainland inlet PFMAs (7-10 and 12) in 2011 and mentioned that other DFO annual summer surveys (high seas salmon and juvenile herring) that frequently observe sardine near those mainland PFMAs also found few in 2011. She explained that because current lead authors and formal reviewers in 2011 were uncomfortable with some of the assumptions and the high level of uncertainty associated with that approach, and because of the absence of confirmed sardine catches in the mainland inlets in 2011, that the 2011 mainland inlet biomass expansion was discounted.

Information explicitly presented in the draft SAR pertaining to biomass and migration estimates, harvest guideline results, ecosystem considerations and uncertainty was also presented.

GENERAL DISCUSSION

POINTS OF CLARIFICATION

Biomass estimates and forecasting

The authors clarified that the inshore biomass estimates were calculated from a cumulative list of June to August 31 commercial fishing areas occurring over 2006-2010, based on some overlap with the July/August W.E. Ricker sardine survey.

It was suggested that one could use the Canadian swept volume biomass estimate to calculate the quota option rather than the US stock assessment estimate multiplied by a migration rate. Canada currently calculates the annual migration rate from the ratio of Canadian survey biomass and US assessment biomass estimates. It was proposed using the Canadian survey biomass only and multiplying by 15% harvest rate. The Canadian survey that is used in the calculation and the US assessment are based on different types of information with different degrees of uncertainty. If the Canadian numbers were incorporated in the US assessment, the estimate of biomass off BC from the model would be more compatible with the population estimates. However, biomass from the trawl survey is sufficient to be used to set the quota and it is un- necessary to go through the process of total biomass and migration rate (see Appendix). The author's response was that this issue was discussed at last year's meeting and was not advised due to concerns when annual downward fluctuations of the population occurs, and relates to uncertainty with biomass forecasts.

Population Distribution

Clarification was requested on the use of the sardine population spatial distribution delineated in the slide entitled "Northeast Pacific Population" to confirm the area used in DFO's calculations. Authors clarified that the slide was part of background biology to demonstrate the possible extent of the sardine population range (Baja to northern B.C) and the slide does not relate to calculating biomass.

Ageing methods

The Good, Fair, Poor rating for ageing of sardine otoliths was explained. Good is very clear; if poor, confidence is low. Clarification was requested on ageing techniques and stated that three years ago DFO produced a paper on how to age older fish. It was asked whether DFO intends to incorporate this methodology into routine use since the paper identified age mis-reading of fish older than 4 years. The response was that surface ageing is much faster but ideally the polished method should be used, but if limited resources continue to exist in the future, it may mean ageing fewer fish (with polished methods). The question was raised if the uncertainty in the ageing is being incorporated into biomass calculations. Authors responded that the US uses an ageing matrix with built in uncertainty.

Modelling

It was suggested that a paragraph on how confidence intervals are calculated (bootstrapping) be included in the SAR and the authors replied that a SAR should have minimal explanation of methods but that a reference to Flostrand et al. (2011) can be made. It was also suggested that a definition of the population model's semester be included in the report.

Management

DFO management asked about the status of "Management Strategy Evaluation" work. The response was that no work has been done on this for Canada but that in the U.S. future work is expected to occur evaluating the use of the distribution factor and cut off.

Cut-off and distribution factor

It was asked if there has been any work done post season to see how close the remaining sardine biomass was to the 150 000 fishing cut off. The response was "no" because all the catches from Canada, US and Mexico are independent so no post season calculations are done except to estimate harvest rates. It was noted that if one was to look at the US assessment estimates, the difference between the population biomass estimates and the catches are still greater than the cutoff. It was also asked if, as with the Mexican 13%, the US takes into account Canadian biomass distribution. Authors replied that it doesn't and it was clarified that the Mexican portion does not include the Gulf of California (Sea of Cortez).

DISCUSSION

Commercial bycatch

Concerns were raised over the mention of bycatch in the SAR. Industry representatives believed the statement in the SAR is too easily taken out of context and that there are relatively low levels of bycatch in the sardine fishery. For example the 2011 bycatch of Chinook was far lower than the recreational sector catch. It was also suggested that current and historical observer coverage should be mentioned in conjunction with bycatch issues. The authors maintained that the data in its entirety is not available for public release but that the IFMP (e.g. DFO 2011b) could be referenced as it contains summary information related to bycatch.

Discussion continued regarding the necessity of ecosystem considerations in the SAR. It was stated that one of the directions for Science providing ecosystem advice is how the species fits into the ecosystem and DFO is required to report on habitat impacts including bycatch issues. These issues are raised in order to determine whether or not they warrant further documentation. There was agreement on adding further context to bycatch statements. DFO management explained that through SIAB (the sardine industry advisory board) a bycatch framework is being considered with input from DFO salmon biologists and managers but it has not yet come to the table for advice. These efforts can also be noted in the SAR for context.

Ecosystem role (forage for marine predators)

The statement "harvesting large amounts of sardine from areas that are important forage habitat for sardine predators" on page 11 was determined by industry to be alarmist. Industry stated that they are supporting ecosystem research through a UBC student. Industry maintained that based on the size of the stock, the Canadian fishery is small, compared to Mexico and the US.

It was explained that although there is little direction to take any explicit science and management action to address ecosystem considerations, it is important because it has been brought up by science as a knowledge gap.

A DFO marine mammal scientist briefly described information related to Humpback Whale recovery as it coincides with the sardine occurrence in B.C. waters (Ford et al. 2009; Nichol et al. 2010). She stated that the extent of sardine in whale diet (or other large predators) is unknown. Other marine mammal populations (such as Fur Seals, sea lions and Harbour Seals) are also in relatively high numbers and showing recovery since being hunted and that these species also feed on sardine.

Some re-wording was suggested for the SAR:
"There is also uncertainty associated with possible ecological effects from the incidental capture of other species (e.g. salmon), and removal of sardine from important foraging habitat of sardine predators (e.g. Humpback Whales). Work is currently being undertaken collaboratively with DFO, the sardine industry and academia to gain a better understanding of this uncertainty."

A suggestion was made to study fat content in sardine.

Biomass expansion factor: mainland inshore inlets

Concern was raised by industry representatives over the removal of the mainland inlets from the expansion factor in the calculation of 2011 biomass. It was stated that the expansion factor was developed using 5 years of data (2006-2010) and the fact that there weren't any fish caught in certain areas in 2011 is not irrelevant. It was also stated that if a constant expansion factor can be determined, that DFO would have more time to address other issues.

An author responded that for the 2011 review there were uncertainty concerns by authors and formal reviewers with the expansion methods. The method was based on whether if a sardine was caught in a PFMA sometime in 2006-2010, then that area would be included. When the method was developed, a lack of fishing in a collective set of PFMAs was not anticipated. In 2011, there is thought to be increased uncertainty because there was no commercial fishing and no sardine were caught in other scientific surveys in or near

mainland PFMAs 7-12 (e.g. targeting June/July and October salmon or August juvenile herring), which frequently capture sardine; furthermore mid summer SSTs appeared relatively cool.

Industry explained that fishing effort is often based on economics. They fish where it is most economically viable. Areas should not be excluded because there was no fishing.

Other anecdotal reports noted sardines were observed flipping on the surface in the northern inlets.

The point that fish being caught down south could be the same as the fish in the northern inlets later in the season was brought up. Alternatively, while the Ricker survey is underway, there are commercial vessels fishing in the inlets.

Frustration was shown that DFO looked at 5 years of data and then took out PFMA's despite their inclusion last year. It was argued that when developing an expansion factor, areas should not be removed unless there is a scientific reason to do so. It was suggested that the inshore are be fixed and reviewed every three or five years.

Concern was shown that there is limited overlap between where the fishery occurs and where the Science survey occurs. It was argued that more evaluation of the determination of inshore areas should be done and additional work done where survey and commercial catch overlap. It was stated that it is unfair to industry to change the areas if fishing habits are based on economics and not fish distribution.

It was pointed out that no fish were caught in area 27 in 2006-2009, and there are other examples of sardines being caught in only 1 year over 2006-2010 or 2006-2011 for a PFMA; thus no constant inter-annual confirmation of sardine presence. Management agreed that there should be rules developed for including and excluding areas.

Consensus was reached to update the draft SAR and include 2011 biomass estimates related to biomass expansion into the mainland PFMAs (7-10 and 12) for provisional advice to managers for 2012 (as was applied for providing 2011 harvest advice); however, this was with the caveat that the method for expansion needs to be re-evaluated prior to use in future assessments given the concerns raised. It was suggested that clear rules for expansion methods be developed, which may include ground-truthing of inlets or using environmental algorithms to determine habitat (satellite, bathymetry). It was pointed out that a request for science advice must be made in order for this work to be done and reviewed under CSAS.

Migration rate and alternative methods for forecasting BC biomass

Industry representatives requested that other migration rate estimates be included in the SAR, such as migration rates based on using fishery-independent methods from both countries (i.e. swept volume trawl surveys from Canada and acoustic-trawl surveys from the US) because both are absolute estimates. The reasoning behind this is that currently DFO uses a fishery independent estimate from the sardine trawl survey with a fishery dependent calculated sardine biomass from the US and these data are not comparable. It was agreed that the acoustic survey done in the US is not the same as the Canadian trawl survey, however, industry argued that it was empirical and therefore more appropriate to use in migration rate calculations than the US assessment model estimate. Historically the US assessment model was used because it was the only data available. Now there is an alternate empirical acoustic time series estimated that industry would like to explore.

Comments related to what U.S. scientists suggested were also discussed (see Points of Clarification and Appendix D), in that if coastwide comparable data sets are available, then compatible data may be available for generating migration rates. The US is planning a US coastwide biomass survey in 2012 and Canada will be participate by conducting their survey at the same time , however since the methodologies used in each area (Canada and US) remain unchanged it is likely the same issue regarding migration rate calculation will also remain. There is also an interest to conduct gear comparisons and intercalibration between Canadian and US survey vessels.

A US representative stated that the US plans on looking at the Canadian survey to provide information on scaling. He said that in terms of migration rate of older and larger sardine observed in Canada as a proportion of comparable older and larger sardine in the population, the migration rate is probably much higher than 15% (or other estimates of migration used in recent Canadian harvest guideline equations). Currently there have been no studies to address questions pertaining to effects of fishing on large sardine versus small sardines in the population. An electronic acoustic tagging study is being planned for 2012 (summer or fall releases from Oregon or Washington), which may provide some information on movements into southern Canadian waters (POST receivers).

There was debate on why and what was more scientific, an assessment model result or an acoustic trawl survey result. It was pointed out that it is not an appropriate time to add things to the SAR without a request for science advice and without a proper review of the new data and methods.

Industry recommended forming a working group prior to April SIAB meeting to discuss determining future migration rates. This was deferred to DFO management, science and SIAB to organise if warranted.

A document on alternative forecasting methods was presented by Ron Tanasichuck (see Appendix D). It was determined that these methods can be reviewed by the authors for future consideration.

CONCLUSIONS & RECOMMENDATIONS

- Estimates of 2011 biomass and migration rates representing mainland inlet PFMAs 7-10 and 12 should be added to the SAR and included in harvest guideline determinations.
- Due to high levels of uncertainty associated with inshore area biomass extrapolation especially in the absence of sardine observations from some inshore PFMAs, a re-evaluation of the method should be completed to develop rules associated with estimating sardine biomass in unsurveyed areas.
- Given the uncertainty associated with the B.C. harvest guideline and forecasting methods, additional consideration of alternative harvest guidelines and/or alternative biomass forecasting methods is recommended.

ACKNOWLEDGEMENTS

The Chair would like to acknowledge the work of the authors for a well written paper and providing quality advice. Thank you to the Rapporteurs for capturing the important details of the review. Thank you to Nic Dedeluk for administrating the webinar and coordinating the meeting details. Finally, thanks to the participants of the review for providing valuable input into the CSAS process.

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APPENDIX A: AGENDA

Regional Peer Review (RPR)
Centre for Science Advice Pacific
AGENDA
Pacific Regional Science Advisory Process
January 10, 2012
Pacific Biological Station, Nanaimo, BC
Chairperson: Sean MacConnachie
Tuesday January 10, 2012

9:00	Welcome & Introductions	Sean MacConnachie
9:15	Review Agenda & Housekeeping	Sean MacConnachie
9:30	CSAS Overview & Meeting Procedures	Sean MacConnachie
9:45	Review of Terms of Reference	Sean MacConnachie
10:00	Presentation: Pacific Sardine 2011 seasonal biomass and migration in British Columbia and harvest advice for 2012	Linnea Flostrand
10:30	Break	
11:00	Group Discussion to identify issues and topics needing further discussion	RAP Participants
11:30	Science Advisory Report (SAR): Develop consensus on: Key findings & conclusions Uncertainties Ecosystem considerations Advice for Management / harvesting strategies Recommendations for future work Other	RAP Participants
12:20	Lunch Break	
1:00	Finalize Science Advisory Report	RAP Participants

APPENDIX B: ATTENDEES

Centre for Science Advice Pacific
Regional Peer Review Participation Plan

Meeting Title: Sardines Jan 10, 2012

DFO / External	Last Name	First Name	Affiliation	Email	Attend Jan. 10, 2012
DFO	Bassett	Sandra	DFO,Science	Sandra.Bassett@dfo-mpo.gc.ca	A
DFO	Boldt	Jennifer	DFO, Science	Jennifer.Boldt@dfo-mpo.gc.ca	A
DFO	Cleary	Jaclyn	DFO, Science	Jaclyn.Cleary@dfo-mpo.gc.ca	A
DFO	Detering	Jackie	DFO, Science	Jackie.Detering@dfo-mpo.gc.ca	A
DFO	Edwards	Andrew	DFO, Science	Andrew.Edwards@dfo-mpo.gc.ca	A
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DFO	Mah	Jordan	DFO, FAM	Jordan.Mah@dfo-mpo.gc.ca	A
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DFO	Nichol	Linda	DFO, Science	Linda.Nichol@dfo-mpo.gc.ca	A
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DFO	Tanasichuk	Ron	DFO, Science	Ronald.Tanasichuk@dfo-mpo.gc.ca	A
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External	Sweetnam	Dale	NOAA	dale.sweetnam@noaa.gov	W

APPENDIX C: TERMS OF REFERENCE

Terms of Reference

Pacific Sardine 2011 Seasonal Abundance and Migration in British Columbia and Harvest Advice for 2012-01-06
Pacific Regional Advisory Process
January 10, 2012
Nanaimo, British Columbia
Chairperson: Sean MacConnachie

Context

The Pacific Sardine (*Sardinops sagax*) is a pelagic schooling fish that is found in British Columbia (B.C.) waters, and when abundant, occupies coastal waters from Baja California to southeast Alaska. In winter and spring months, most of the sardine population resides in waters off the California coast during peak spawning periods. Prior to and during summer months, large aggregations of sardine migrate from key spawning habitat and migrate to more northern waters mainly to forage, but migratory patterns can be affected by population size and oceanographic conditions.

Data from commercial sardine catches and summer research trawl surveys have been used to estimate sardine biomass and migration rates in relation to providing harvest advice (DFO 1999, 2001, 2009, 2011). Scientists in the United States (U.S.) conduct coastwide annual assessments of the population's abundance, recruitment, age and length compositions, based on integrating data from research surveys and commercial catches primarily conducted in U.S. waters, although catch and length data from Canadian sources are also included (e.g. Hill et al 2010).

The most recent framework for setting annual allowable catch of Pacific Sardine in B.C. waters results from *Regional Advisory Processes* conducted in 1999, 2001, and 2009. The framework is based on the product of three factors: 1) the current coastwide sardine biomass estimate resulting from the assessment conducted by U.S. analysts; 2) the U.S. annual harvest rate (DFO 2001; Schweigert and McFarlane 2001), which has been 15% in recent years, but is a function of sea surface temperature and U.S. harvest control rules; and, 3) the application of an estimated rolling average seasonal migration rate of sardine to B.C. waters (DFO 2009; DFO 2011). Rolling average seasonal migration rate estimates have been based on regional sardine biomass estimates in B.C. waters divided by corresponding estimates of the coastwide population biomass. Estimates of sardine biomass in B.C. have been based primarily on data from DFO west coast of Vancouver Island surveys and, beginning in 2011, have included inshore biomass estimates derived from extrapolating mean sardine research trawl catch densities from west coast of Vancouver Island surveys to spatial estimates of inshore areas where sardine has been commercially harvested (DFO 2011; Flostrand et al 2011).

Fisheries Management has requested updated information on seasonal sardine biomass and migration into B.C. waters and advice applicable to the current harvest management framework. Because the assessment method was recently reviewed (DFO 2011), updated estimates and corresponding harvest advice will be provided to Regional Advisory Process participants for review in the form of a draft Canadian Science Advisory Secretariat (CSAS) Science Advisory Report.

Objectives

- Provide estimates of the 2011 mid-summer B.C. Pacific Sardine seasonal biomass and migration rate;
- Provide the average migration rate for the 2009, 2010 and 2011 seasons.
- Provide potential catch options for the 2012 fishing season resulting from applying the previously approved management framework.
- Identify any specific concerns, uncertainties or information gaps that should be considered when setting the total allowable catch for the 2012 fishing season.

Science Advisory Report to be reviewed:
Pacific Sardine 2011 seasonal abundance and migration in British Columbia and harvest advice for 2012

Expected Publications

CSAS Proceedings
CSAS Science Advisory Report (1)

Participation

DFO Science Branch
DFO Fisheries and Aquatic Management Branch
BC Ministry of Fisheries
Commercial and recreational fishing interests
First Nations organizations
Non-government organizations

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DFO. 2009. Proceedings of the Pacific Scientific Advice Review Committee (PSARC) meeting for the assessment of scientific information to estimate Pacific sardine seasonal migration into Canadian waters. DFO. Can Sci. Advis. Sec. Proceed. Ser. 2009/034

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Hill, K.T., Lo, N.C.H., Macewicz, B.J., Crone P.R. and Felix-Uraga, R. 2010. Assessment of the Pacific Sardine resource in 2010 for U.S. management in 2011. Pacific Fishery Management Council, Nov 2010 Briefing Book, Agenda Item I.2.b. Attachment 2. 128 p.

Flostrand, L., Schweigert, J., Detering, J., Boldt, J., and MacConnachie, S. 2011. Evaluation of Pacific sardine (*Sardinops sagax*) stock assessment and harvest guidelines in British Columbia. DFO. Can Sci. Advis. Sec. Res. Doc. 2011/096.

Schweigert, J. and McFarlane, G.A. 2001. Stock assessment and recommended harvest for Pacific sardine in 2002. DFO. Can. Sci. Advis. Sec. Res. Doc. 2001/126. 12p.

Schweigert, J., McFarlane, G.A., and Hodes, V. 2009. Pacific sardine (*Sardinops sagax*) biomass and migration rates in British Columbia. DFO. Can. Sci. Advis. Sec. Res. Doc. 2009/088. 14p.

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APPENDIX D: ADDITIONAL MATERIAL

Some comments about the biomass, migration rates and others regarding the Pacific Sardine off BC.

by Nancy Lo

Four issues: 1. Quota computation, 2. Variance computation based on bootstrap, 3. Migration rates, and 4. Effect of fishing on large fish off Canada and young fish off California

1. Quota computation based on biomass from survey and not on total biomass from the model and migration rates

Nancy Lo suggested using the Canadian computed biomass rather than the US stock assessment. Canada currently calculates from the total Canadian biomass and the migration rate and then applies this to the computed US ratio, the quota. Lo suggested going from Canadian biomass only and multiplying by 15%. The Canadian survey that is used in the calculation and the US assessment are all different information. She stated that she does not think these two are compatible. If the Canadian numbers were incorporated in the US assessment this issue would be resolved. However, biomass from the trawl survey is sufficient to be used to set the quota and it is unnecessary to go through the process of total biomass and migration rate.

The estimation procedures in Ron Tanasichuk's report is an improvement of the current procedure assuming the linear relationship of two sets of data: 1. population biomass of lag 1 and 2, the migration rate and the total biomass. However the biomass.2012 is still rely on the biomass estimates from the model and 'migration rate'. For the biomass of coming year, I would only use the relationship between biomass of year I and year i-1, lag 1 model based on biomass off BC from the trawl survey to forecast the biomass in BC in the coming year based on the relationship between lag 1 years, which may not be restricted to the linear relationship. Then one can apply 0.15 to the forecasted biomass off BC.

2. Variance computation based on bootstrap:
Add a paragraph to describe the procedure of computation. The bootstrap can be also used to estimate of biomass.

3. Migration rates: Current computation of migration rate is the ratio of biomass estimate from trawl survey and the total biomass from the model, which is not quite compatible. Sandy Mcfarlane suggested to use trawl data and acoustic data from the coastal wide surveys conducted in the past years, say: 2006, 2008 and 2011 to compute migration rates. This estimate of migrate rate may be an improvement over the current method. However, the data from trawl and acoustic are not on the same scale and thus the resulted migration rate is still likely to be bias. Regardless, migration rates have to be computed from the same data source, say either from swept- area method or from acoustic method and not from combined data source. Another method for migration rates would be based on the difference of the biomass between spring and summer as done for sardine off US (Lo et al. 2010), which requires additional survey in spring.

4. Effect of fishing on large fish off Canada and young fish off California on the sardine population: Young fish are recruits and large fish are more fecund with better quality of eggs than younger fish . Older fish are leaders of the population and valuable to the sustainability of the population (ICES 2007). Studies need to be carried out to check the effect of fishing mortality on older fish and young fish on the population to determine the maximum of fishing mortality for these two groups of fish.

Flostrand, Linnea et al. 2012, draft. Pacific Sardine seasonal biomass and migration in British Columbia and harvest advice for 2012.

ICES 2007. Report of the workshop on testing the Entrainment Hypothesis (WKTEST), 4-7 June 2007, Nantes, France. ICES Document CM 2007/LRC:10. 111pp.

Lo, N. C. H., B. J. Macewicz, and D.A. Griffith, 2011. The migration of Pacific Sardine off US coast in 2003-2005. Journal of Marine Biology 87(3):395-412.
http://dx.doi.org/10.5343/bms.2010.1077

Tanasichuk, Ron (this proceedings) Possible errors in the maximum harvest option calculatins for the 2012 Pacific Sardine fishery in British Columbia

For the quota computation for say 2012 (q.2012):
q.2012= Biomass.2012 x 15% (1)

where the biomas.2012 is the biomass estimate for 2012 off BC.

The current procedure to estimate biomass for 2012 is through the total biomass estimated from the stock assessment and migration rate where the migration rate for any given year is estimated by the average of three migration ratios in recent years. The migration rate of any given year is estimated by the ratio of the biomass estimates from trawl survey and the total biomass from the stock assessment performed at the SWFSC:
Biomass.2012 = total biomass.2012 x migration rate.2012
=total biomass in 2012 x (biomass.2009/total biomass.2009 + biomass.2010/total biomass.2010+ biomass.2011/total biomass.2011) /3 (2)

where total biomass.2012 is the total biomass estimated from the stock assessment.
migration rate.2012 =(biomass.2009/total biomass.2009 + biomass.2010/total biomass.2010+ biomass.2011/total biomass.2011)/3 (3)
Thus the above method is to divide the biomass from trawl survey by the total biomass to get the migration rate, which was later multiplied by the total biomass from latest stock assessment to get the biomass for upcoming year (Table 2 and 3 of Flostrand et al. 2012)
A straightforward way to estimate the biomass.2012 is based on biomass obtained from the three trawl surveys to be consist with the current estimation procedure for the average of three migration rates (which later was shown not optimal by Tanasichuk (this proceeding)). Thus there would be no need to use estimate of the total biomass from the stock assessment and the migration rates

Biomass.2012.2=~~total biomass in 2012 x~~ (biomass.2009/~~total biomass.2009~~ + biomass.2010/ ~~total biomass.2012 +~~ biomass.2011/~~total biomass.2011~~)/3
= (biomass.2009 + biomass.2010+ biomass.2011)/3 (4)

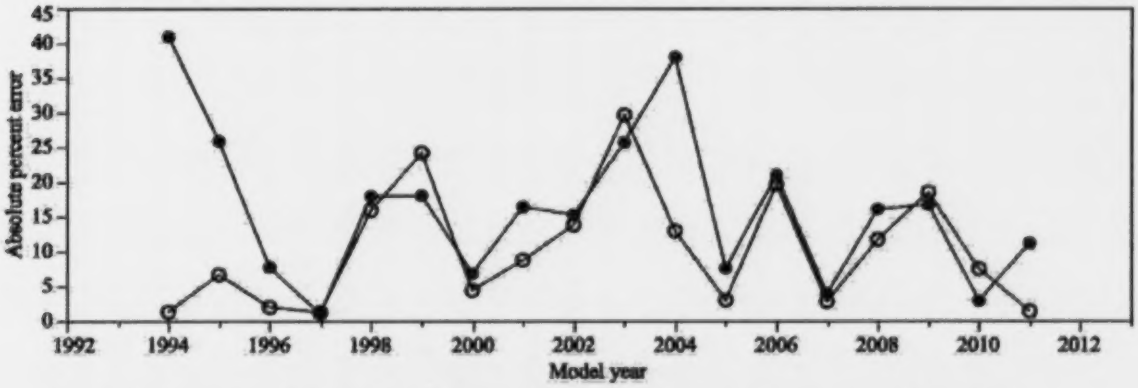
The alternative estimate of biomass in 2012 (biomass.2012.2) based on equation (4) is 141,034 mt while the estimate of the biomass.2012 based on equation (2) is 150,235 mt (table 2 and table 3 of biomass report by Flostrand et al. 2012)

Possible errors in the maximum harvest option calculations for the 2012 Pacific Sardine fishery in British Columbia

by Ron Tanasichuk

The maximum harvest options for the British Columbian sardine fishery are calculated by multiplying the model estimate of adult (age 1+) biomass for the entire population by the average migration rate for the last three seasons and by an exploitation rate of 15%. It appears that there is a more accurate forecast of biomass for the coming season, and the recent time trend in migration rate renders the use of a running average to estimate migration rate as inappropriate.

a) Forecasting biomass



Biomass is forecasted as the model estimate of adult biomass for the year before the fishery; however, the regression of observed biomass on the previous year's biomass provides a more accurate forecast. Annual estimates of adult biomass were read off of Fig. 5 of the Working Paper. Below is the result of a regression analysis of adult biomass regressed on the previous year's biomass. I compared the accuracy of the forecasts based on the previous year's biomass estimate with that of the forecast based on the regression. Below is a graph that shows the absolute percent error of the forecasts using both approaches; the open circles identify the error for the forecast based on the regression, and the closed circles identify the error for the forecast based on the previous year's biomass. The average percent error is 10.3 for the regression forecasts and 16.2 for the previous year's biomass forecasts.

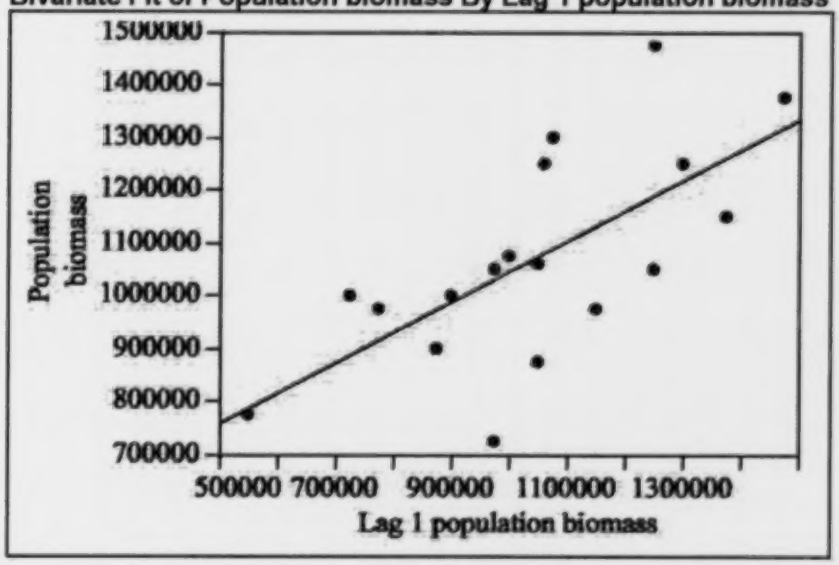
b) Forecasting migration rate

The current methodology uses a running 3-year average migration rate but this is inappropriate because of recent time trends in migration rate. I used the migration rates for the core area and core plus inshore areas in 2006 and 2008, that were presented in Flostrand et al. (2011), and the migration rates for 2009-11 presented in this year's Working Paper.

I found significant time trends in migration rate to the core and the core plus inshore areas. The figures below show the results of the analyses. The predicted migration rates are 8% for the core area and core plus inshore areas.

Data Table=2012 Sardine assessment

Bivariate Fit of Population biomass By Lag 1 population biomass



Linear Fit
Population biomass = 468496.37 + 0.5756016*Lag 1 population biomass

Summary of Fit

RSquare	0.45467
RSquare Adj	0.420586
Root Mean Square Error	152562.7
Mean of Response	1070000
Observations (or Sum Wgts)	18

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	3.1049e+11	3.105e+11	13.3400
Error	16	3.7241e+11	2.328e+10	Prob > F
C. Total	17	6.829e+11		0.0021

Parameter Estimates

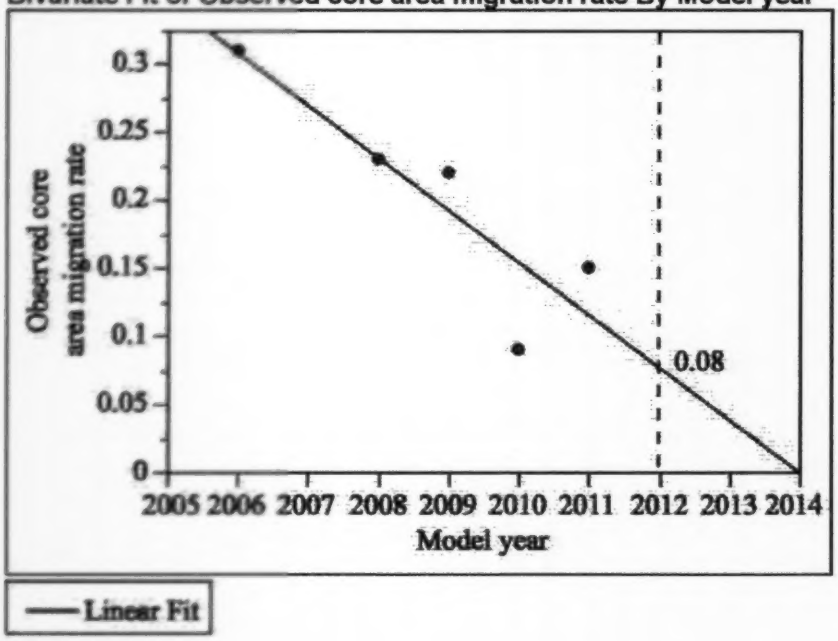
Term	Estimate	Std Error	t Ratio	Prob>|t|

Intercept	468496.37	168567.5	2.78	0.0134
Lag 1 population biomass	0.5756016	0.157596	3.65	0.0021

Data Table=2012 Sardine assessment

Fit Y by X Group

Bivariate Fit of Observed core area migration rate By Model year



Linear Fit

Observed core area migration rate = 77.565946 - 0.0385135*Model year

Summary of Fit

RSquare	0.784025
RSquare Adj	0.712033
Root Mean Square Error	0.044897
Mean of Response	0.2
Observations (or Sum Wgts)	5

Analysis of Variance

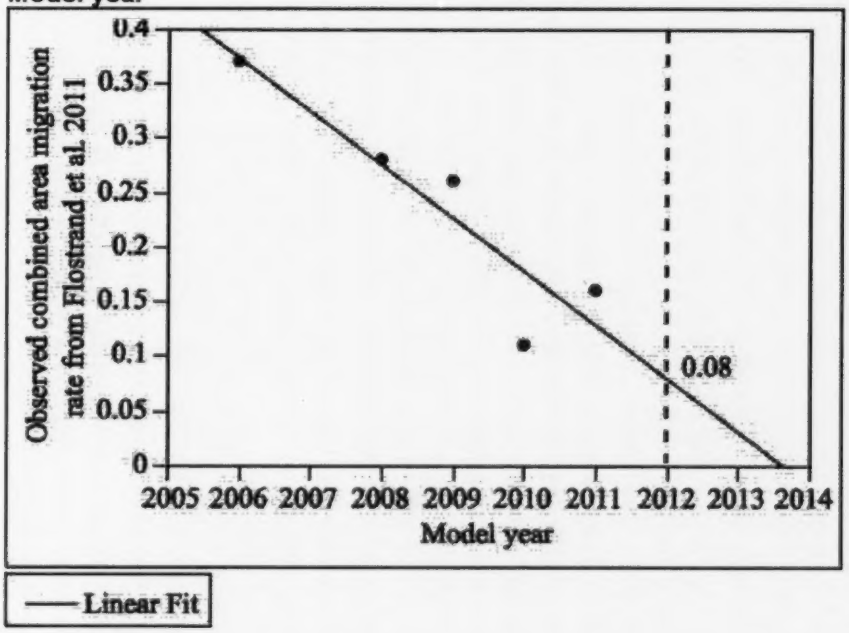
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.02195270	0.021953	10.8905
Error	3	0.00604730	0.002016	Prob > F
C. Total	4	0.02800000		0.0457

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	77.565946	23.44369	3.31	0.0454

Model year	-0.038514	0.01167	-3.30	0.0457

Bivariate Fit of Observed combined area migration rate from Flostrand et al. 2011 By Model year



Linear Fit

Observed combined area migration rate from Flostrand et al. 2011 = 98.504324 - 0.0489189*Model year

Summary of Fit

RSquare	0.840867
RSquare Adj	0.787822
Root Mean Square Error	0.047268
Mean of Response	0.236
Observations (or Sum Wgts)	5

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.03541730	0.035417	15.8521
Error	3	0.00670270	0.002234	Prob > F
C. Total	4	0.04212000		0.0284

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	98.504324	24.68143	3.99	0.0282
Model year	-0.048919	0.012287	-3.98	0.0284

c) Revised maximum harvest option forecast

The regression forecast of adult biomass for 2012 is 1,044,098 tonnes. The revised forecast for the core and core plus inshore areas is 1,044,098 x 0.08 x 0.15=12,529 tonnes.

A comment on the utility of the current forecasting methodology:

I think that the current approach to providing harvest advice for Pacific Sardine in British Columbia is a misdirected use of resources. The apparent error in the model forecasts overwhelms any estimation of migration rate into Canadian waters. I think that it would be more appropriate to take an approach that is analogous to that used to harvest sardine in Australia, where a constant catch used. I recommend that a constant harvest rate, for example 5% of the forecasted adult biomass, be used to control Pacific Sardine fishing in British Columbia. This would be precautionary and likely provide for a viable fishery. The constant harvest rate approach would have provided maximum harvest options ranging between 23,750 and 73,750 tonnes based on the 1993-2011 time series presented in the Working Paper. I suggest that, in the spirit of co-operation, biological sampling of the catch continue.

Flostrand, L., Schweigert, J., Detering, J., Boldt, J., and MacConnachie, S. 2011 Evaluation of Pacific Sardine stock assessment and harvest guidelines in British Columbia. DFO Can. Sci. Advis. Sec. Res. Doc. 2011/096. http://www.dfo-mpo.gc.ca/Csas-sccs/publications/resdocs-docrech/2011/2011_096-eng.pdf